Human Spaceflight Futures: Four Options

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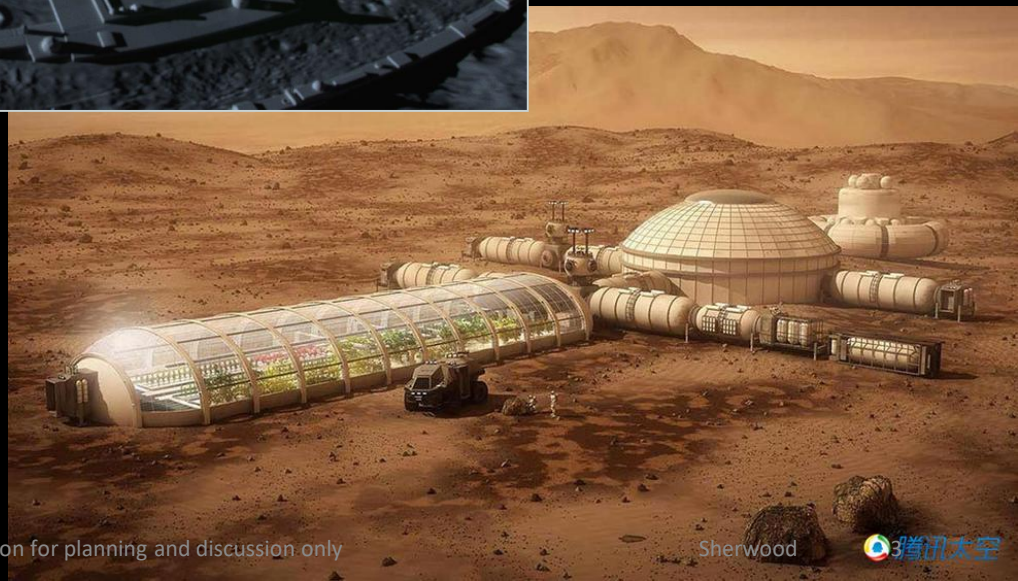
What is human spaceflight?

Perhaps on its way, someday, to this



Every HSF idea arises from among four visions

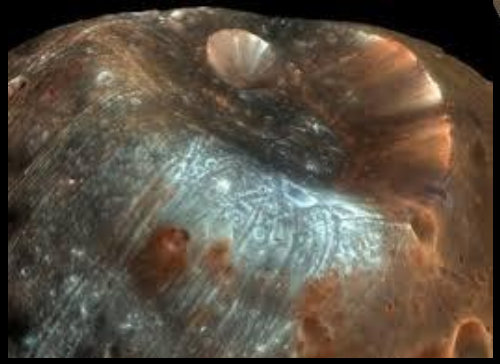
Explore

Exploit

Experience

Expand

Explore



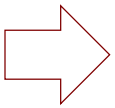
The *Explore* Vision

Extend human presence "where no one has gone before"

Cultural myth: The Hero

Template: Lewis and Clark

10^{11}
&
40 years



- Very big deep-space propulsion
- Sustain human health and assembled systems for years, billions of km from home
- Land 25x bigger and heavier payloads on Mars
- Figure out how to use local resources
- Avoid contaminating the places where life might be

Humans on Mars, finally


Experience

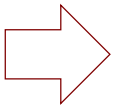
The *Experience* Vision

Hundreds of thousands of people traveling in space every year

Cultural myth: Jet Set

Template: Richard Branson

10^{11}
&
40 years



- "Five 9s" reliable, reusable flight vehicles for launch and entry
- Resort destinations: big volumes, big windows, kitchen science, leisure facilities, artificial gravity
- Commercial space workers

1-hr intercontinental travel. Commercial growth of new travel-related industries. Expansion of Overview Effect.

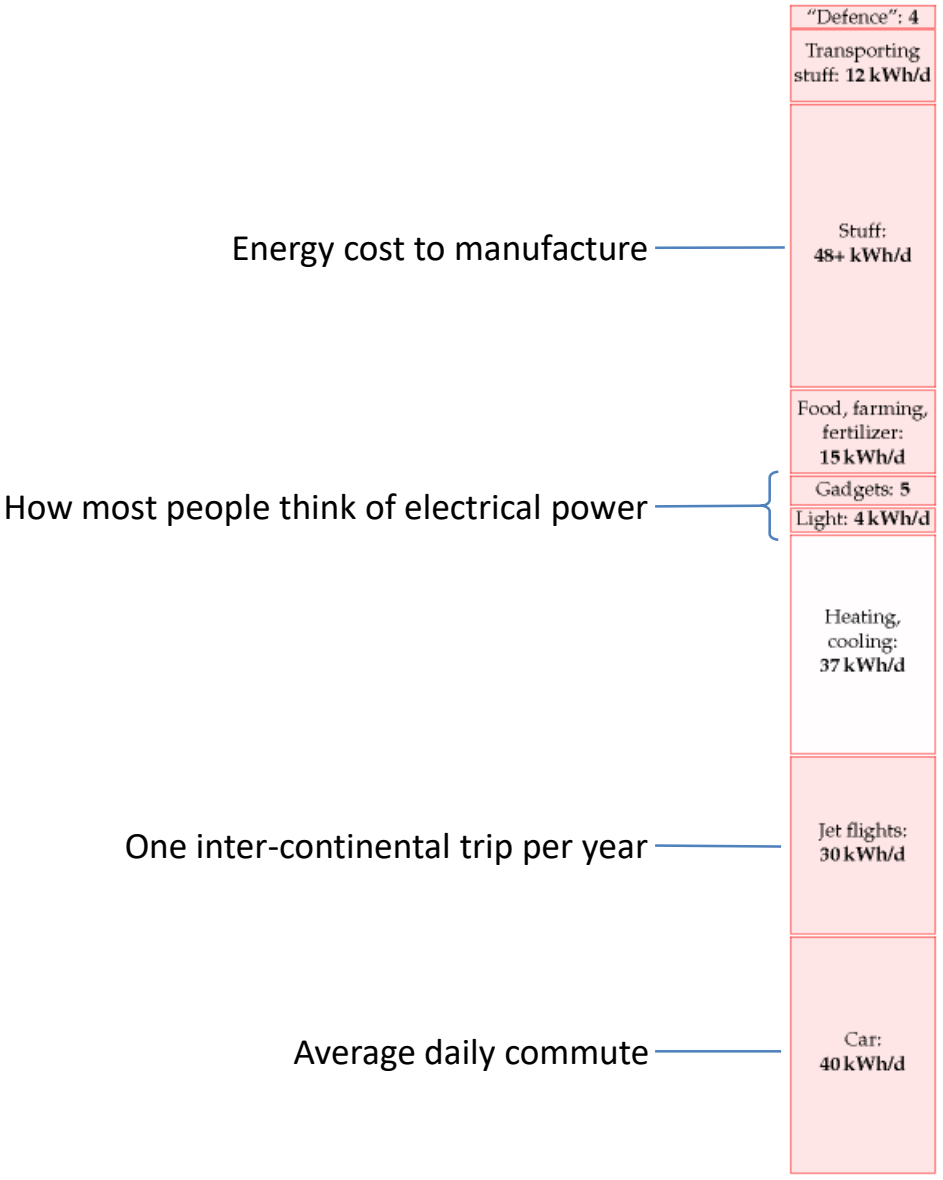

Exploit

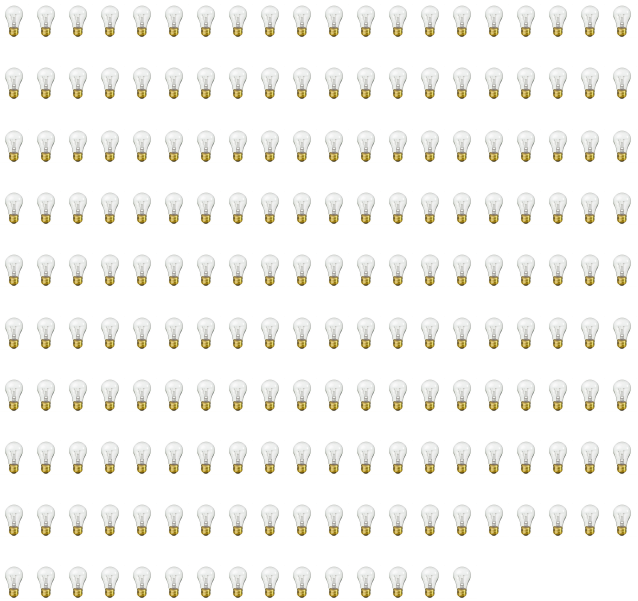
A personalized unit of energy

One 40W bulb, burning all the time ≈ 1 kWh/d

[David MacKay, *Sustainable Energy Without the Hot Air*, *https://www.withouthotair.com/*]

A U.S. life uses almost 200 units per day





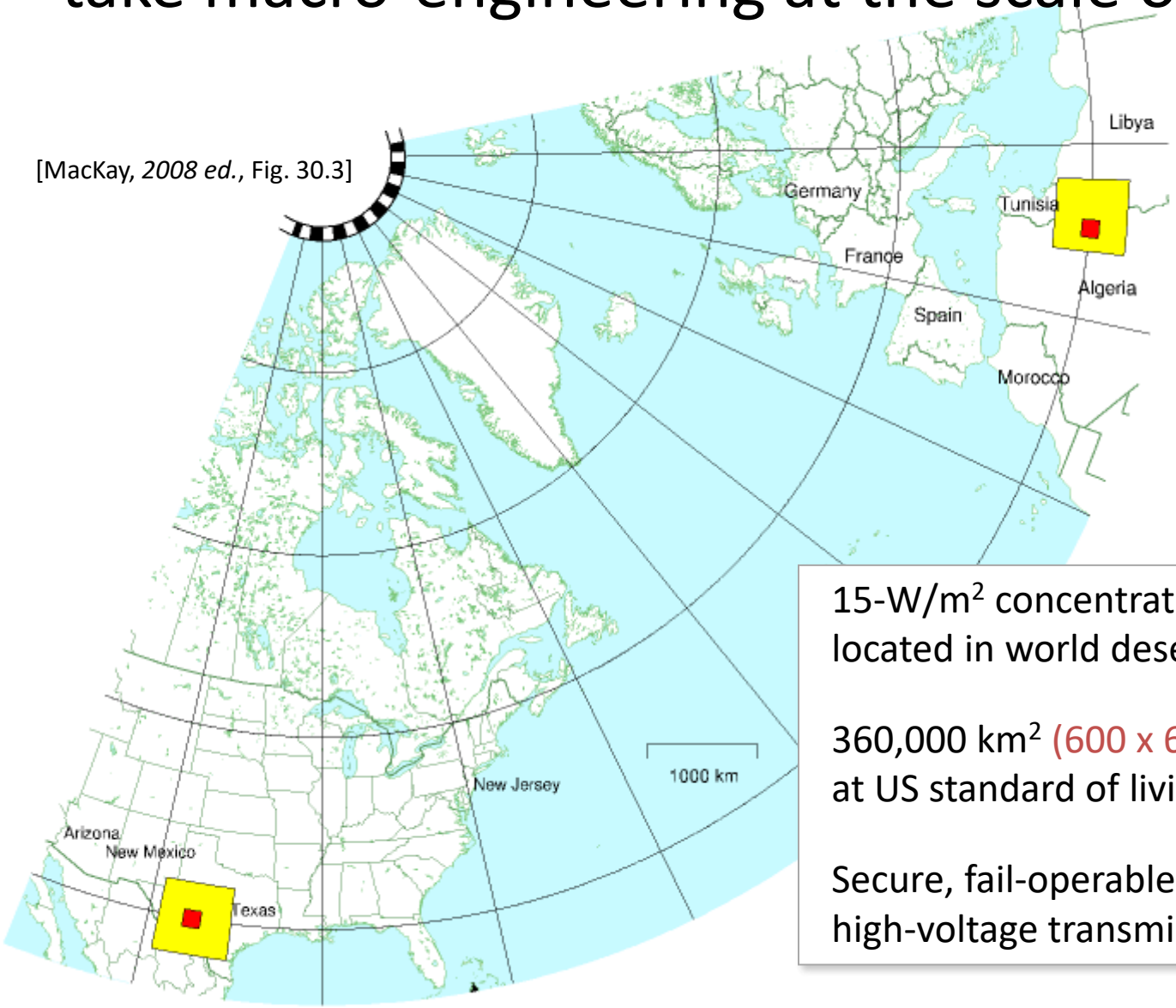
195 kWhr

Each person, every day

[MacKay, *2008 ed.*, p. 103]

Shifting to non-nuclear, renewable sources would take macro-engineering at the scale of the planet

[MacKay, *2008 ed.*, Fig. 30.3]

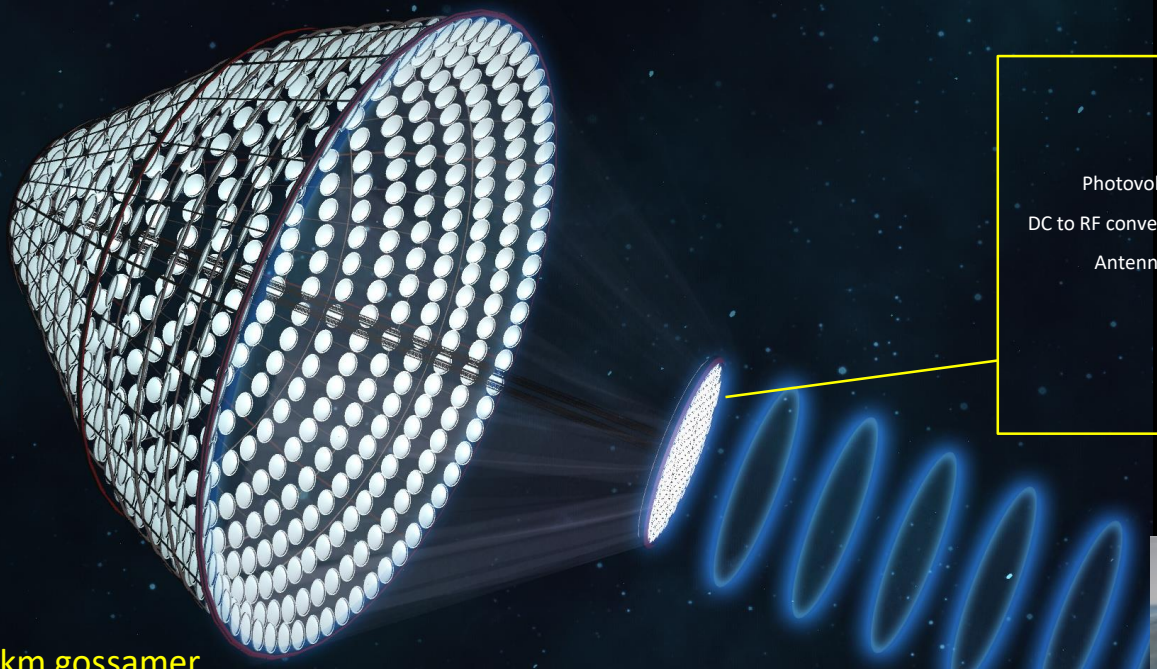


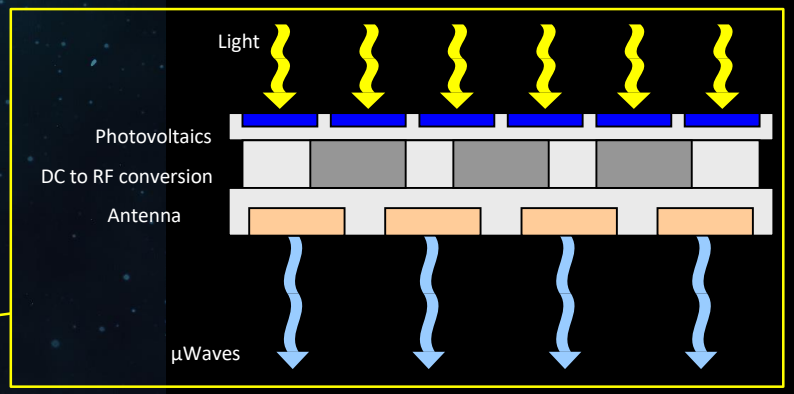
15-W/m^2 concentrating solar power located in world deserts

360,000 km^2 (600 x 600 km) per 1B people at US standard of living

Secure, fail-operable, intercontinental high-voltage transmission networks

Each SPS station in GEO would = a nuclear power plant on the ground





4-km gossamer reflector structure concentrates sunlight

1-km modular, solid-state PV / phased-array assembly transmits microwaves to retro-directive pilot signal from Earth

10-km rectenna array over farmland feeds 1 GWe into terrestrial grid

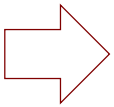
Image credits:
- Hyper-modular SPS concept, *Artemis Innovation Management Solutions LLC*
- Sandwich module, *Paul Jaffe*
- Rectenna image, *University of Maryland*

The *Exploit* Vision

Enable non-disruptive transition to post-petroleum civilization by opening unlimited energy resources for use by Earth

Cultural myth: Green (in both senses)

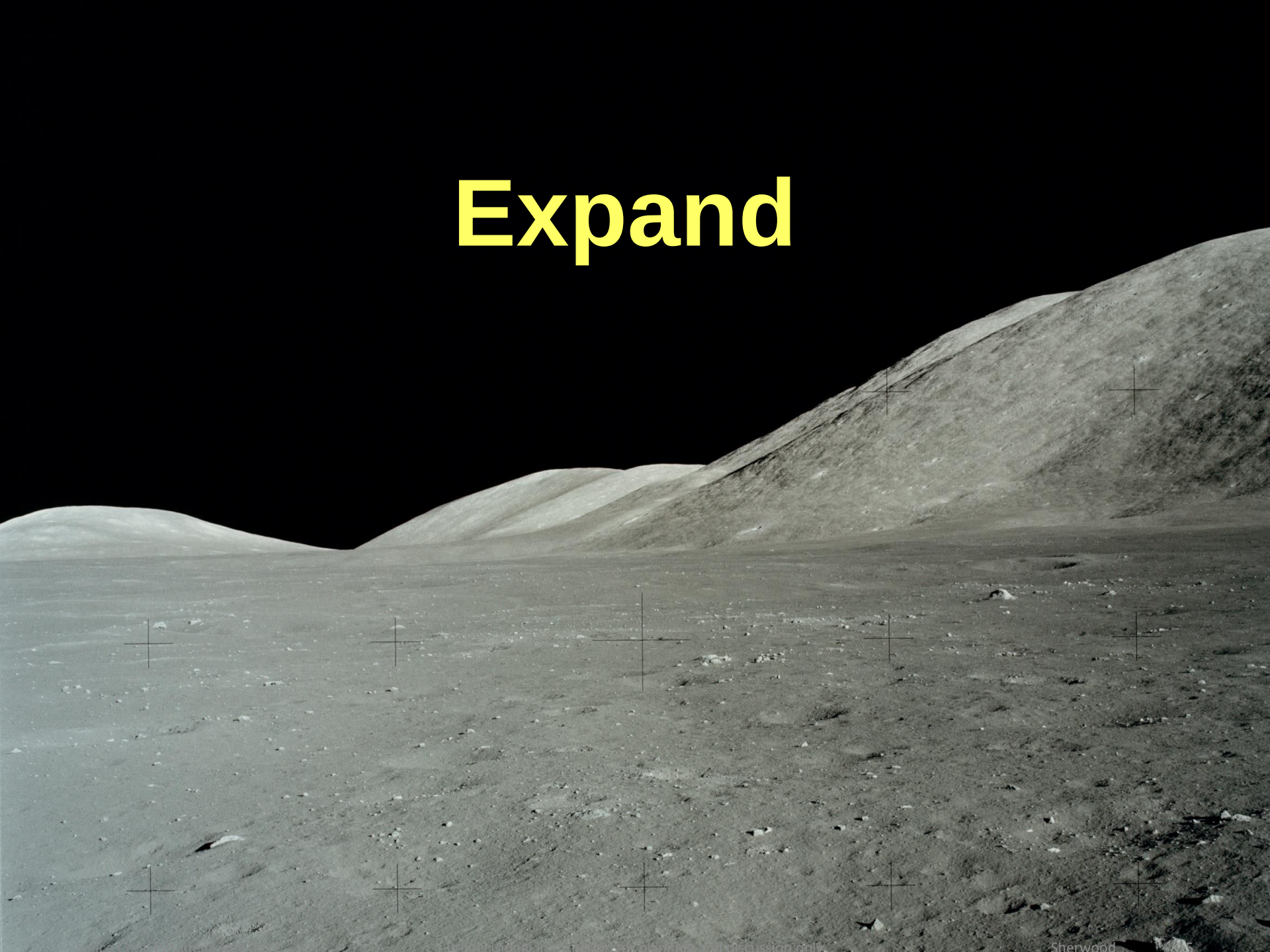
10^{11}
&
40 years



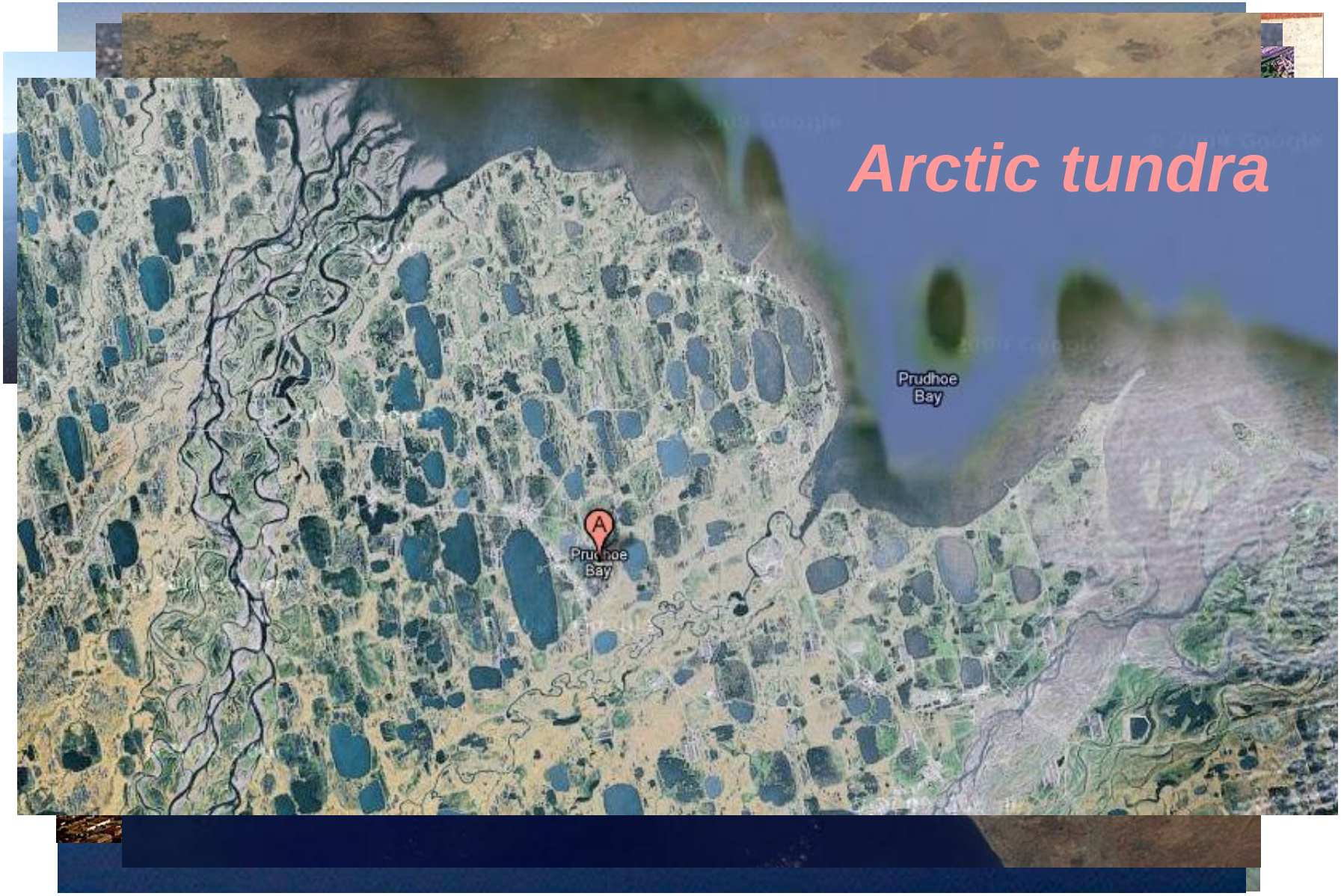
- High-power atmospheric beaming protocols
- High-capacity, economical, green, heavy-lift launch
- Gossamer, hyper-modular space systems
- Very large-scale implementation of space robotics

Limits to growth removed.

Expand



Cities arise in unlikely places



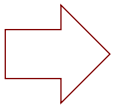
The *Expand* Vision

Settle offworld; establish Earth life and human civilization in space, independently of our homeworld

Cultural myth: Pioneer

Template: Heinlein novels

10^{11}
&
40 years



- Routine heavy traffic from and to Earth
- Space civil engineering, with community-scale life support and food production
- Broadest spectrum of quotidian skills and products
- "Live off the land" and extract resources for export

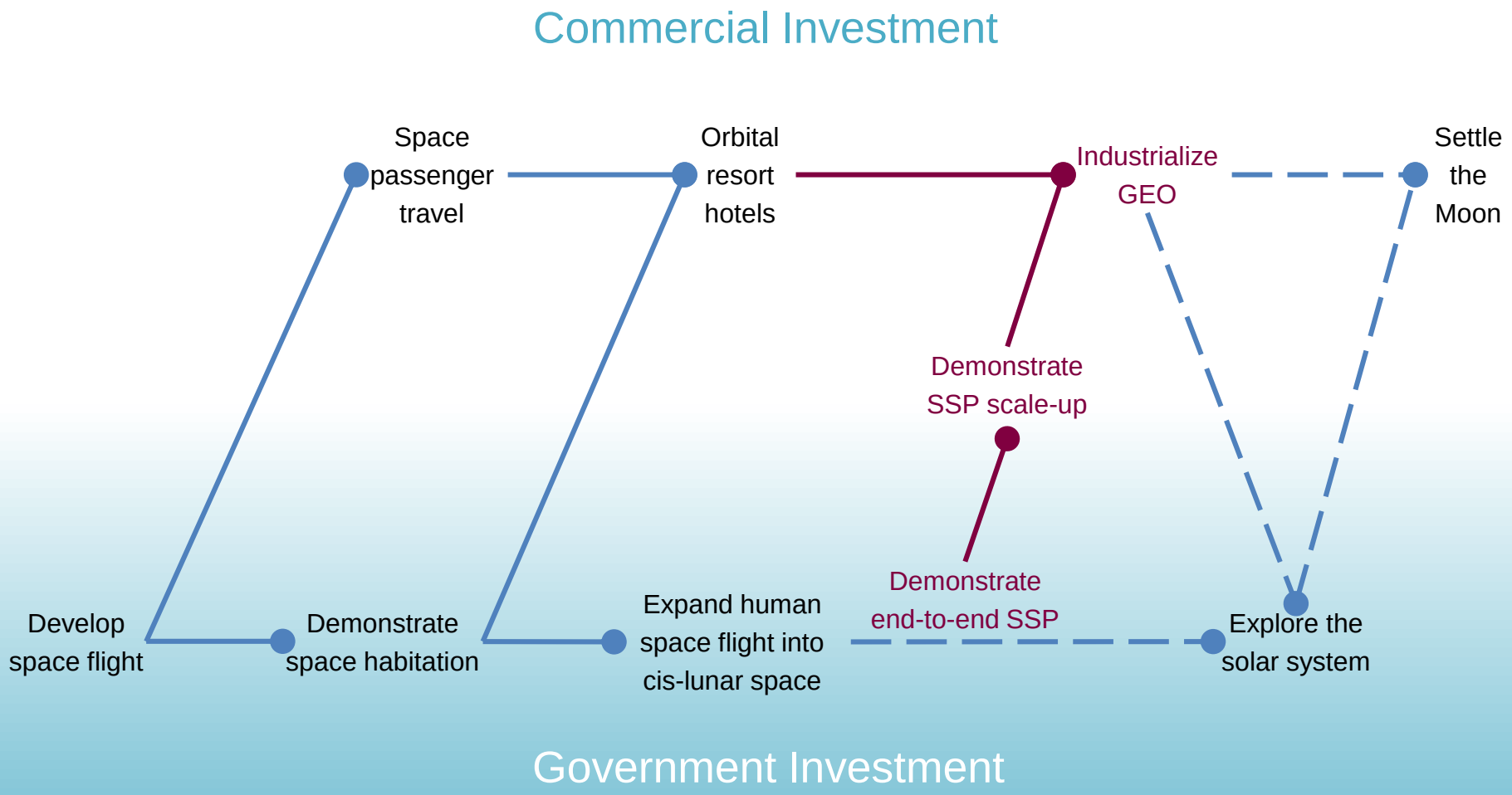
Hundreds of people raising families in space, learning how humanity can live there forever

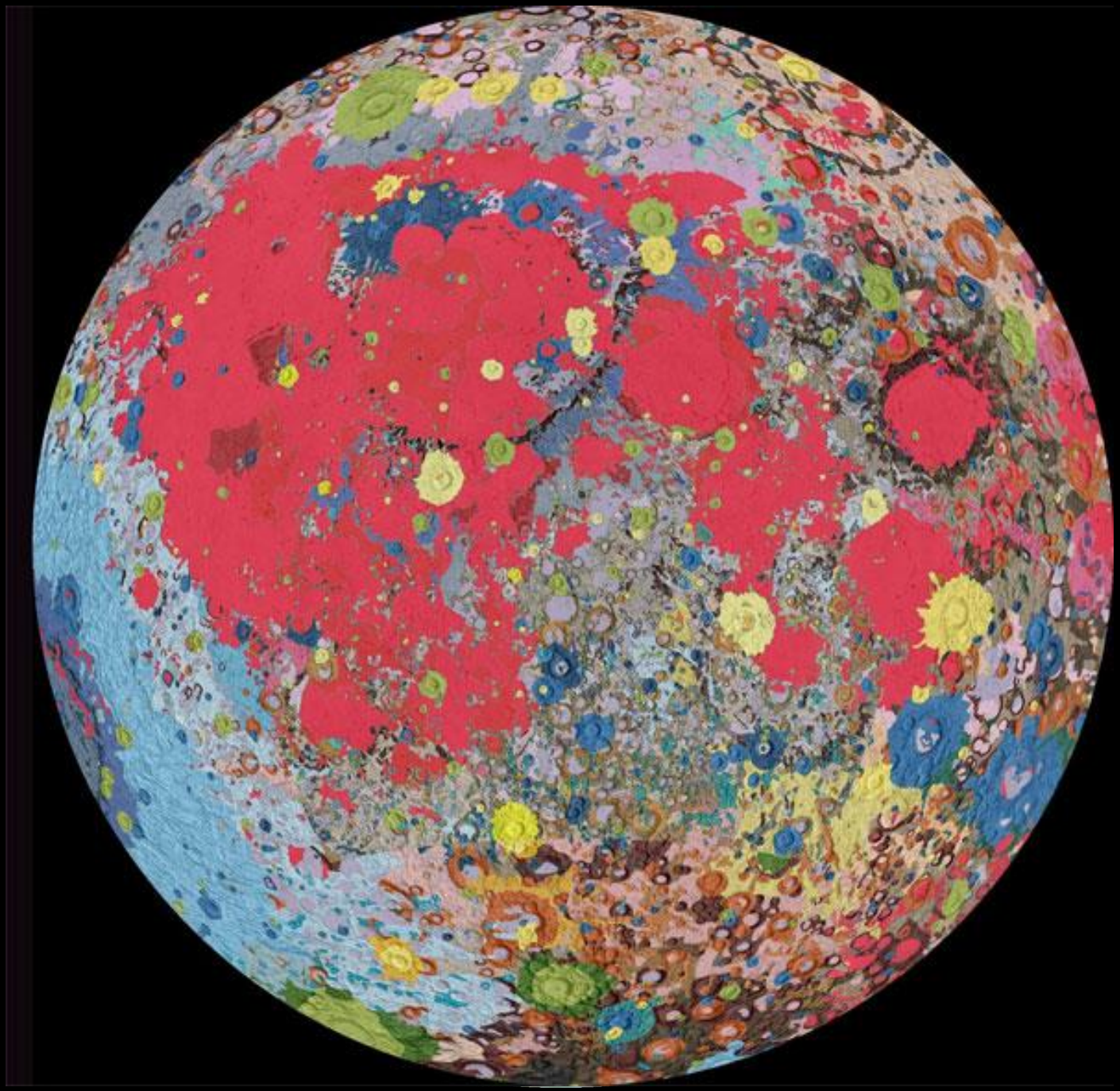
A Moon Village would be feasible, but more complex than ISS

- Power
- Laboratories
- Habitats
- ETO-RTE “shuttle”

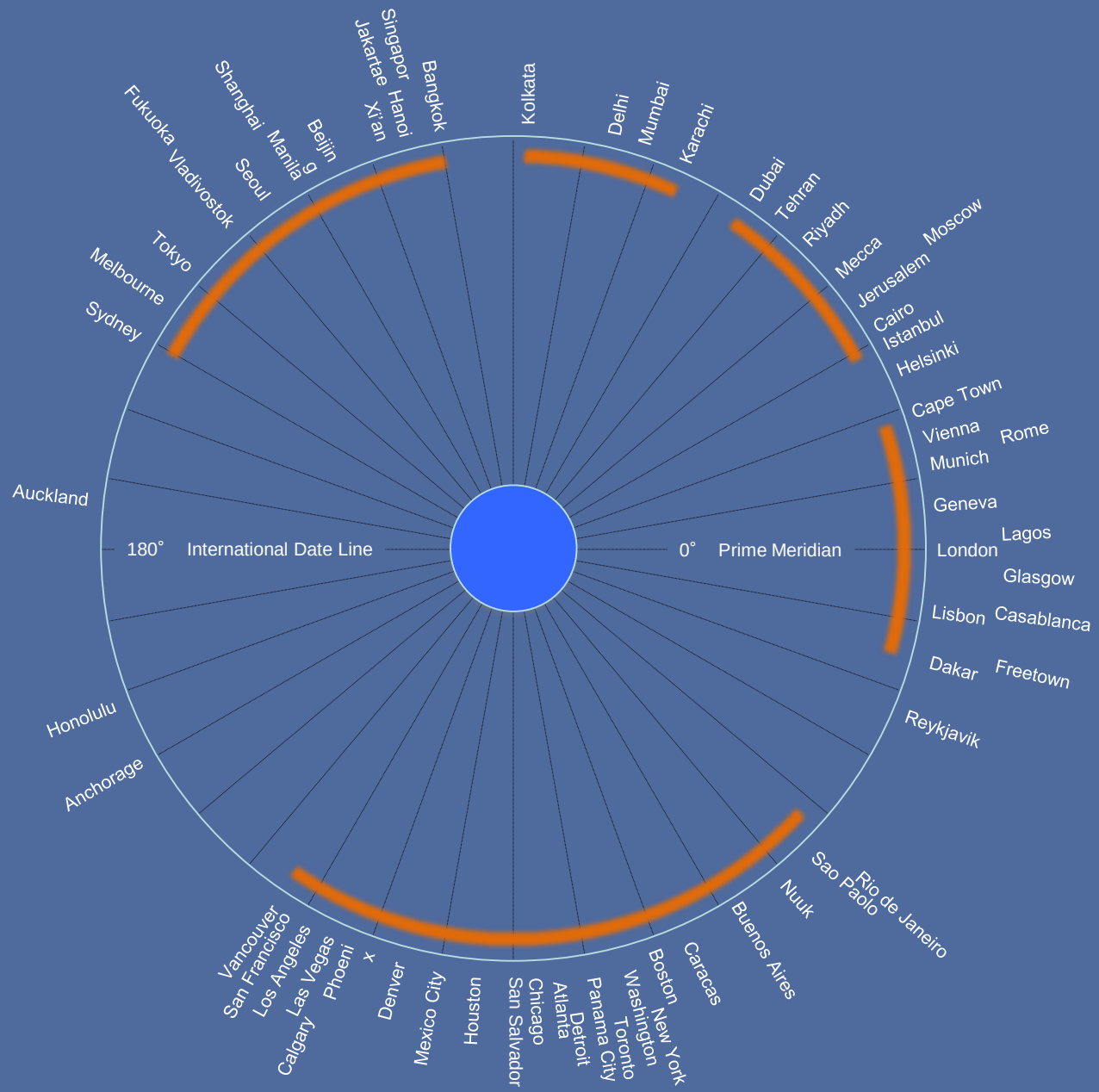
- Power
- Laboratories
- Habitats
- ETO-RTE “shuttle”
- Trans-orbital “shuttle”
- Lander-Ascent “shuttle”
- Surface mobility & construction
- Resource utilization

“When you come to a fork in the road…”





Urban Geography from GEO



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